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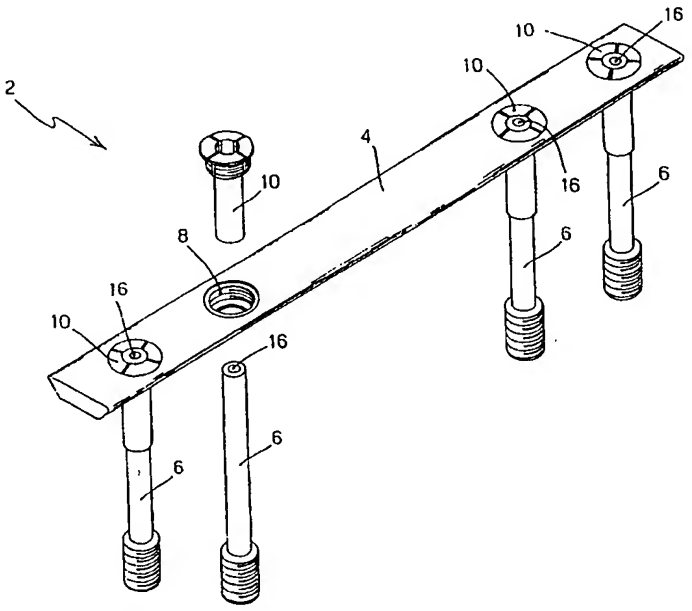
(54) Title: DEVICE FOR FIXING BONE SECTIONS SEPARATED BECAUSE OF A FRACTURE



(57) Abstract: A device (2) for fixing bone sections separated because of a fracture comprises a plate (4) with bores (8) for the fastening to a bone, a plurality of internally hollow barrels (10), screwed in the bores (8) of the plate (4) and a plurality of compression screws (6) adapted to be screwed in the bone and then locked in the barrels (10).

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

DEVICE FOR FIXING BONE SECTIONS SEPARATED BECAUSE OF A FRACTURE

The present invention relates to a device for fixing bone sections separated because of a fracture.

More particularly, the invention relates to a plate and screw assembly for osteosynthesis, allowing immobilising one or more fractures in a long bone, such as a femur or a tibia.

Generally the plates have elongate shape ad are available in different models, depending on the shape and size of the bone they are to be applied to.

For instance, patent application WO 97/08999 discloses a plate for fixing fractures in the end section, or head, of a bone. Such a plate has an elongate portion that can be fastened to the bone through a plurality of screws, and an end portion including a barrel that is inserted into the bone to receive a compression screw. The compression screw is previously screwed into the bone; subsequently, after having located the plate with the barrel, the screw is fastened by a traction screw allowing compression of the plate against the bone.

Generally, compression screws are used in the bone head, whereas conventional screws of small size are used for fastening the plate to the bone shaft.

The barrel, which is integral with the plate, allows a rigid connection of the plate and the screw, thereby eliminating any clearance that might arise between the two parts.

Yet, the presence of the fixed barrel makes the plate application complex, since it is necessary to previously drill a bore in the bone, and hence use of special guides and tools is indispensable.

European patent EP 0 649 635 discloses a plate equipped, at

its end portion, with two parallel barrels adapted to be inserted into the bone head. Also in this case the plate is fastened to the bone through a plurality of conventional screws, whereas compression screws are introduced in correspondence of the barrels. The presence of two barrels further increases the application difficulty, since two perfectly parallel suitably offset bores are to be drilled in the bone so as to allow a precise introduction of the barrels.

An alternative solution to using barrels is disclosed in PCT patent application WO 97/20513. That document discloses a special system for coupling a screw head and a corresponding opening in the plate. More particularly, the screw has an expansion head that, when expanding, becomes tightly locked in an opening of complementary shape in the plate. Yet such a solution, while allowing a certain rigidity in the screw-plate connection and making fixing operations simpler, does not provide the same structural rigidity as the barrels.

It is an object of the invention to provide a plate for osteosynthesis, which is equipped with a plurality of barrels to be coupled with compression screws and which can be readily and safely applied.

The above and other objects are achieved by means of the device made in accordance with the invention, as claimed in the appended claims.

The plate made in accordance with the invention can be manufactured in different shapes and sizes to suit to different bone shapes and, thanks to the modularity of the barrels, can be used for different fracture types. Moreover, thanks to the provision of removable, and hence interchangeable, barrels, the plate can match screws of different lengths and sizes.

The above and other objects of the invention will become more

readily apparent from the following description of a preferred embodiment, with reference to the accompanying drawings, in which:

- Fig. 1 is a perspective view of an osteosynthesis device made in accordance with the invention;
- Fig. 2 is a partial cross sectional view of a compression screw used in a device made in accordance with the invention;
- Figs 3 and 4 are a side and a top view, respectively, of a barrel used in a device made in accordance with the invention;
- Fig. 5 is a schematic side view of an osteosynthesis device made in accordance with the invention, when applied to a femur;
- Fig. 6 is a side view of a variant embodiment of an osteosynthesis device made in accordance with the invention;
- Fig. 7 is a side view of the device shown in Fig. 6, when applied to a femur;
- Fig. 8 is a front view, partly in cross section, of a compression screw made in accordance with a second exemplary embodiment of the present invention;
- Fig. 9 is a cross sectional view of a barrel that can be coupled with the screw shown in Fig. 8;
- Fig. 10 is a perspective view of a plate including a plurality of barrels and screws made in accordance to Figs. 8 and 9;
- Fig. 11 is a front view of a compression screw made in accordance with a third exemplary embodiment of the present invention; and
- Fig. 12 is a cross sectional view of a barrel that can be coupled with the screw shown in Fig. 11 and the plate shown in Fig. 10.

Referring to Fig. 1, a device 2 for fixing bone sections separated because of a fracture comprises a plate 4 with four threaded bores 8, four barrels 10 and four compression screws 6.

Barrels 10 are separate from plate 4 and therefore are

interchangeable at will; they may have different lengths and internal diameters, depending on the requirements and on the bone type. The illustrated embodiment shows four identical barrels, and is suitable for fractures in the shaft of bones like femur or tibia.

Each compression screw 6, shown in detail in Fig. 2, has no widened head and comprises an elongate body, with an external diameter corresponding with the internal diameter of barrel 10, a threaded end 14 insertable into the bone, and a hexagonal hollow 16 allowing screwing screw 6 in the bone by means of a suitable screw-driver tool, not shown.

Barrels 10 are instead shown in detail in Figs. 3 and 4. Each barrel 10 has an elongate and internally hollow cylindrical portion 18, projecting from plate 4 in order to penetrate into the bone, and an externally threaded frustoconical end portion 20. End portion 20 has two mutually perpendicular slots 24, 26, passing through the barrel axis. Such slots allow barrel end portion 20 to be radially compressed while the barrel is being screwed in plate 4, thereby gripping elongate body 12 of the corresponding compression screw 6.

Barrels 10 are screwed in plate 4, after screws 6 have been inserted into the bone, through a suitable tool, not shown in the drawings, which e. g. engages slots 24 and 26. To prevent the simultaneous rotation of screws 6 while the barrels are being screwed, it is possible to simultaneously use the same tool as previously used for screwing the screws, now in order to prevent their rotation.

Fig. 5 shows the device shown in Fig. 1 when applied to a femur 22 where a fracture line 23 is present. Screw 6 and barrels 10 are inserted into the bone, whereas plate 4 remains outside the bone and ensures the structural rigidity of the system. The length

of each barrel 10 and each screw 6 may be chosen at will, to suit the bone type and the position, depending on the requirements.

The possibility of separating barrels 10 from the corresponding plate 4 makes the application of the above described device to the fractured bone considerably simpler.

The application is carried out by the following steps:

- plate 4 is laid on the bone with barrels 10 already screwed, but in reverse position, i. e. projecting away from the bone;
- the bores for compression screws 6 are drilled by using the barrels as guides;
- plate 4 is removed and the bores are partly widened for the subsequent barrel insertion;
- compression screws 6 are screwed in the bone;
- the plate without the barrels is positioned;
- barrels 10 are screwed and automatically grip the elongate bodies of screws 6 thereby locking the screws into position.

Fig. 6 shows instead a variant embodiment of a device 42 for fixing bone sections, made in accordance with the present invention. In particular device 42, which has been designed for fixing a fracture in a femur head, comprises a plate 40 having an elongate portion 44, into which two barrels 10 of the kind previously described and shown in Figs. 3 and 4 are introduced, and an inclined end portion 46, adapted to house a different kind of barrel 30.

Barrel 30, that has a greater size than the other barrels 10, has a cylindrical threaded end portion 41 where the two slots typical of barrels 10 are not provided. Indeed barrel 30 is screwed in a corresponding threaded bore in plate 40, but it is not used to grip the body of the corresponding compression screw 32. Indeed compression screw 32, having an elongate body 36 and a threaded end 34, also includes a separate head 38, 39 that is screwed in a

corresponding bore provided in body 36 of the screw itself. Head 38, 39 is actually a screw, having a threaded body 38 and a widened portion 39, which screw is introduced and abuts into a cavity in barrel 30, so as not to project from the plate.

Barrel 30 and compression screw 32 allow attaining a stronger compression of the bone sections, whereas barrels 10 allow using headless compression screws.

Fig. 7 shows the device of Fig. 6 when applied to a femur 22. Screws 6 fasten plate 40 to the bone shaft, and screw 32 compresses the two bone sections separated by fracture line 23.

Figs. 8 and 9 show a second exemplary embodiment of a screw-barrel pair made in accordance with the present invention.

Screw 60, shown in detail in Fig. 8, comprises an elongate body 64 having at one end a threaded portion 66 adapted to penetrate into the bone, and at the other end a frustoconical head 68. Head 68 also has, in its upper part, a hexagonal cavity 70 intended to receive a screw-driving tool.

The characteristics of threaded portion 66 and the screw size, for instance the length and the diameter of the screw, may vary depending on the kind of fracture and of bone.

Fig. 9 shows instead in detail barrel 50 into which screw 60 is inserted for being screwed in the bone. Barrel 50 has an externally threaded cylindrical first portion 54 defined upwardly by an abutment ring 59, and an elongate cylindrical portion 58. The latter projects from the plate onto which the barrel is screwed and penetrates into the bone thus guiding screw 60.

Through-hole 56 inside barrel 50 has constant cross-sectional size within elongate cylindrical portion 58, whereas it has a frustoconical and outwardly open shape within the cylindrical first portion 54, so as to perfectly match the body and the head of screw 60.

Actually screw 60, when being screwed in the bone, is locked inside barrel 50 thereby eliminating any clearance that may arise between the two parts.

Barrel 50 may be coupled with an osteosynthesis plate like that shown in Fig. 10, which shows a further variant embodiment of a device 92 for fixing bone sections made in accordance with the present invention. Osteosynthesis plate 90, which can be coupled with several barrels 50, has four seats 96 with a cylindrical internal thread, adapted to house four corresponding barrels 50a - 50d. Four screws 60a - 60d are then used to fasten plate 90 to the bone.

When a barrel 50 is screwed into a corresponding threaded bore 96 in the plate, as shown in Fig, 10, abutment ring 59 is received into a corresponding ring cavity 94 formed in the plate about threaded bore 96, so that there is no projecting portion.

Figs. 11 and 12 show a third exemplary embodiment of a screw-barrel pair, made in accordance with the present invention, which may be coupled with a plate of the type shown in Fig. 10, i. e. a plate having internally threaded cylindrical seats 96.

Screw 70, shown in detail in Fig. 11, comprises a threaded elongate body 72 and a head 74 equipped, in its upper portion, with an hexagonal hollow, not shown in the drawing, adapted to receive a screw-driver tool. The kind of thread and the size of screw 70, e. g. its length and diameter, may vary depending on the fracture and the bone kinds.

Fig. 12 shows instead in detail barrel 80 into which screw 70 is received for being then screwed in the bone. Barrel 80 has an externally threaded cylindrical first portion 82 upwardly defined by an abutment ring 86, and an elongate cylindrical portion 84. The latter projects from the plate onto which the barrel is screwed and penetrates into the bone thus guiding screw 70.

The through-hole inside barrel 80 is internally threaded and has in its upper portion a seat 88 adapted to house head 74 of screw 70. The internal thread assists in the penetration of screw 70 into the bone, during the application, and at the same time it allows locking the screw within the barrel when the screw itself is completely screwed.

Interchangeability of the screw-barrel pairs with respect to the plate being used allows choosing the plate kind independently of the kind of screw/barrel used, depending on the requirements and the bone kind. Plate 90 shown in Fig. 10 is suitable for instance for fractures in the shaft of bones like femur or tibia.

The application of plate 90 by means of the screw devices previously disclosed with reference to Figs. 8, 9 and 11, 12 is carried out by the following operations:

- plate 90 is laid on the bone for drilling the four bores where screws 60 or 70 will be subsequently screwed;
- plate 90 is removed and the bores are somewhat widened for the subsequent insertion of the projecting portions of barrels 50 or 80;
- barrels 50, 80 are screwed in plate 90 and the latter is positioned on the bone, thereby making the projecting portions of the barrels penetrate into the corresponding bores;
- screws 60, 70 are screwed in the bone and, when becoming locked within the barrels, they fasten plate 90 to the bone.

Interchangeability of the barrels allows anyway obtaining a high flexibility of employ, since it is possible to choose each time the most suitable screw kind, and the corresponding barrel, by using thus a conventional plate.

Patent claims

1. A device (2; 42; 92) for fixing bone sections (22) separated because of a fracture, the device comprising:
   - a plate (4; 40; 90) with a plurality of bores (8; 96) for fastening said plate to said bone by means of screws;
   - at least one barrel (10; 30; 50; 80), internally equipped with an axial through-hole, said barrel being located in correspondence with one of said bores and projecting from said plate towards the bone;
   - at least a compression screw (6; 32; 60; 70) adapted to be received in said barrel (10; 30; 50; 80) and screwed in said bone;

   characterised in that said at least one barrel (10; 30; 50; 80) and said plate (4; 40; 90) are separate pieces that can be rigidly coupled by screwing said barrel in a threaded bore (8; 96) in said plate.
2. A device according to claim 1, wherein said barrel (10) has an elongate cylindrical portion (18) adapted to penetrate into said bone, and a threaded frustoconical end portion (20) where two mutually perpendicular slots (24, 26) pass through the barrel axis are formed, which slots allow said end portion (20) to become radially compressed during screwing of the barrel into the plate.
3. A device according to claim 2, wherein said end portion (20) of the barrel, during screwing of the barrel (10) in the plate (4), grips the end portion of said compression screw (6), thereby locking it within the barrel.
4. A device according to claim 1, wherein said barrel (30; 50; 80) has an elongate cylindrical portion (18) adapted to penetrate into said bone, and a threaded end portion (41; 54; 82) adapted to be screwed in a corresponding threaded bore (8; 96) in said

plate (44; 90).

5. A device according to claim 4, wherein said barrel (30) has a longitudinal internal cavity into which a compression screw (32) is inserted, said compression screw comprising an elongate body (36) with a threaded end (34), which is partly introduced into said cavity, and a head (38, 39) which is screwed, at the side opposite to said barrel, in said elongate body (36) to lock said compression screw (32) in said barrel (30).

6. A device according to claim 5, wherein said head (38, 39) is a screw including a threaded portion (38), which is screwed in the elongate body (36) of said compression screw (32), ad a widened end portion (39), which abuts against the barrel (30) thereby allowing compressing the plate (40) against the bone.

7. A device according to claim 4, wherein said through-hole of said barrel (50) has a frustoconical, outwardly open first portion (56), and said screw (60) has a frustoconical head (68), of complementary shape to the frustoconical first portion (56) of the hole of the barrel (50), so that, when said screw (60) is inserted into the barrel (50) and screwed in the bone, the head (68) is locked by compression within the corresponding frustoconical portion (56) of the barrel (50).

8. A device according to claim 7, wherein said elongate cylindrical portion (58) of the barrel (50) has smaller external diameter than said threaded first portion (54).

9. A device according to claim 4, wherein said through-hole of said barrel (80) is internally threaded to engage a threaded elongate body (72) of the compression screw (70).

10. A device according to claim 7 or 9, wherein said cylindrical first portion (54; 82) of the barrel (50; 80) is defined upwardly by an abutment ring (59; 86) that, when the barrel is screwed in the plate (90), is received in a corresponding annular cavity (94)

formed about the bore (96) receiving said barrel.

11. A device according to any preceding claim, comprising a plurality of threaded bores (8; 96) each adapted to receive a barrel (10; 30; 50; 80) for locking a corresponding compression screw (60; 70).

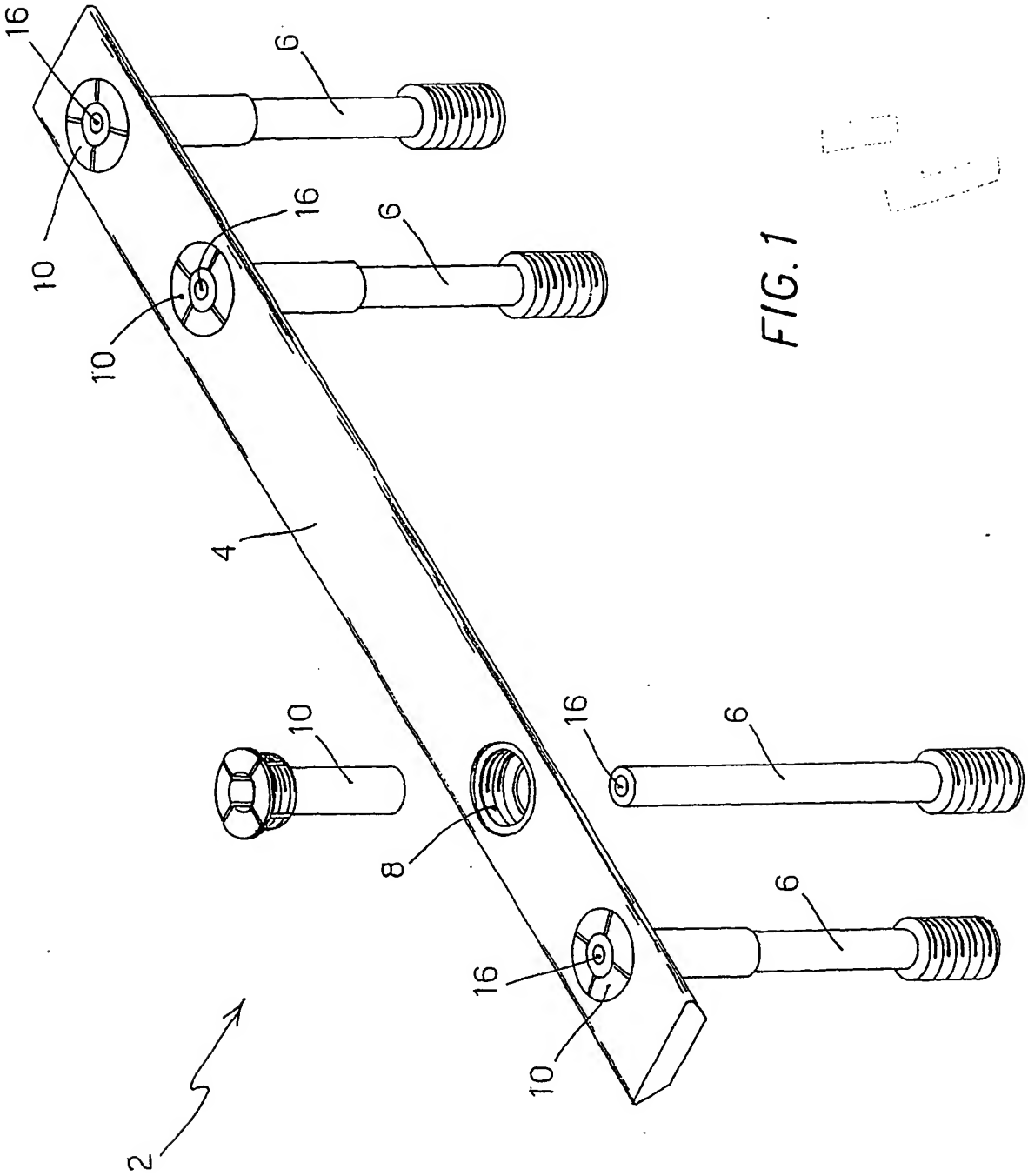

FIG. 1

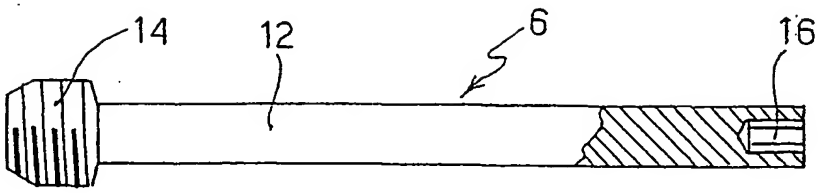

FIG. 2

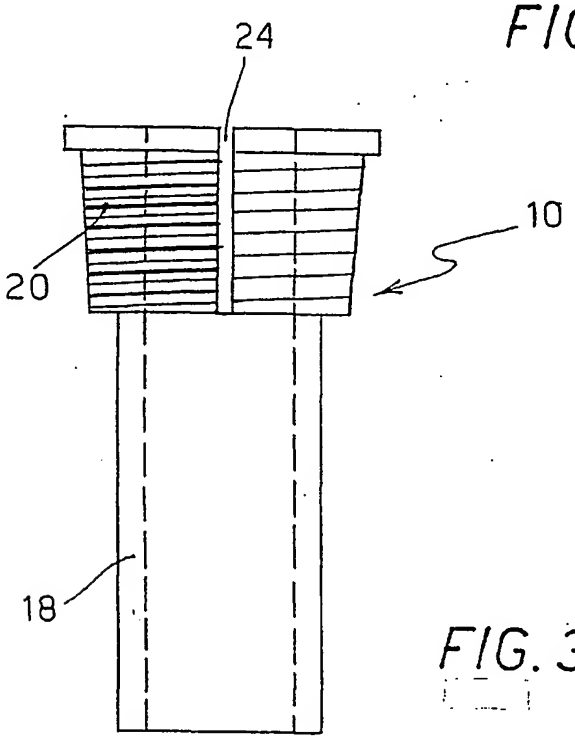

FIG. 3

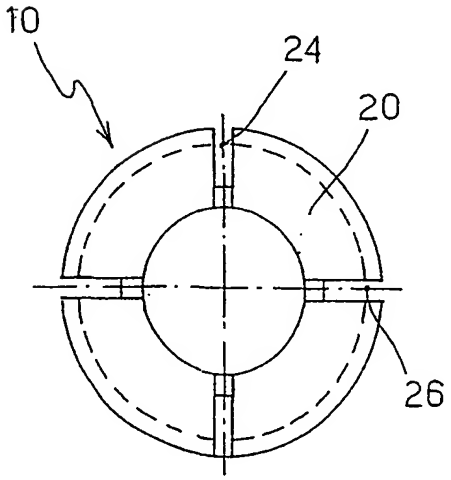

FIG. 4

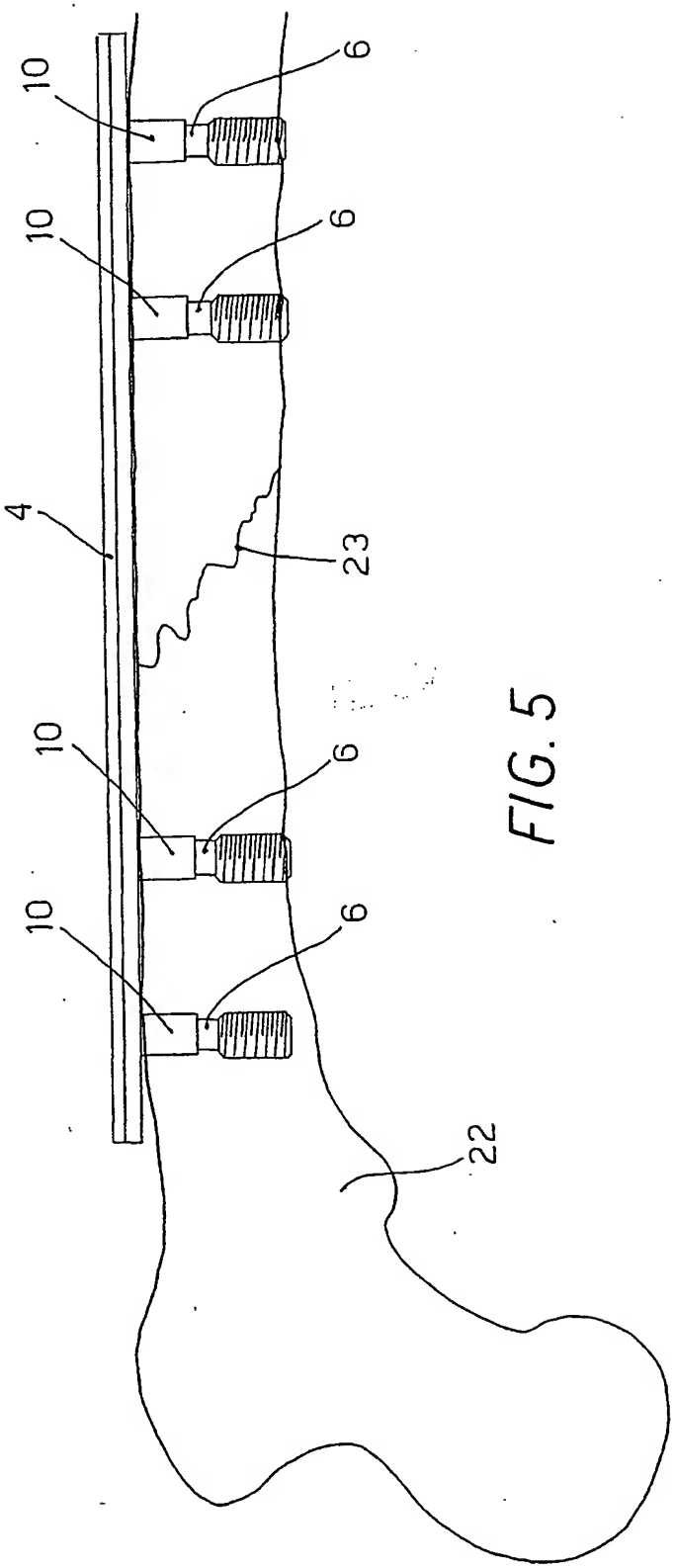

FIG. 5

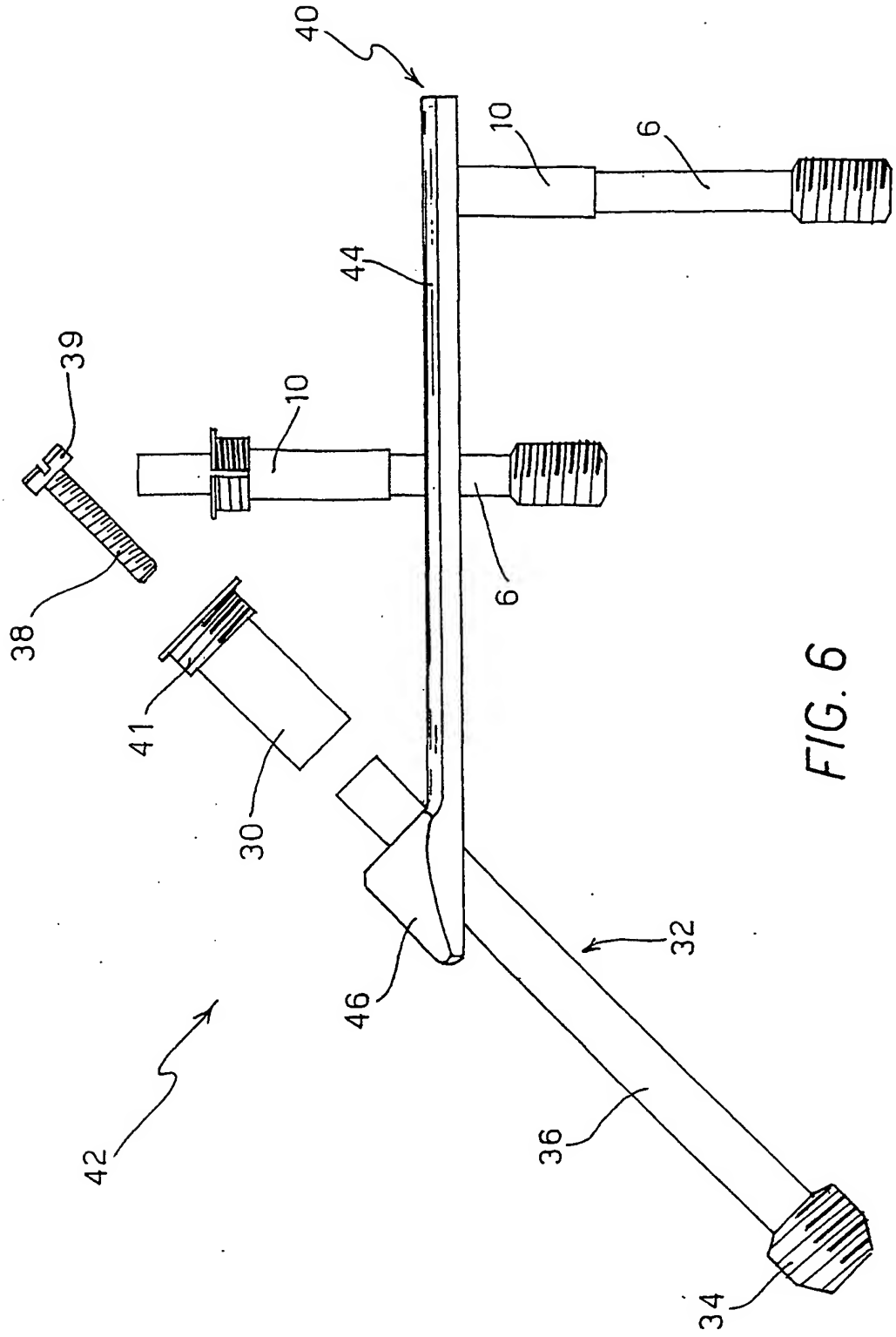

FIG. 6

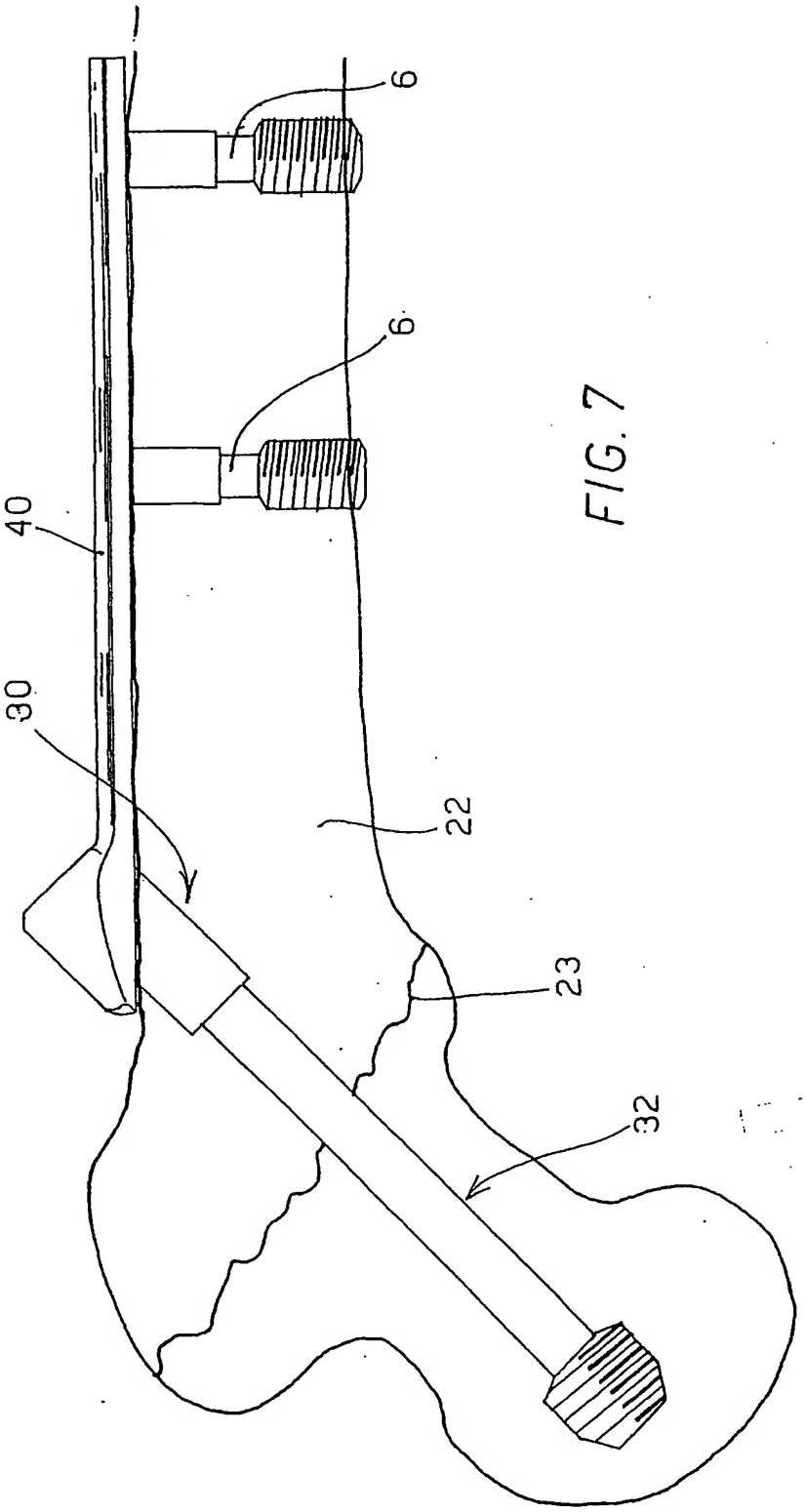

FIG. 7

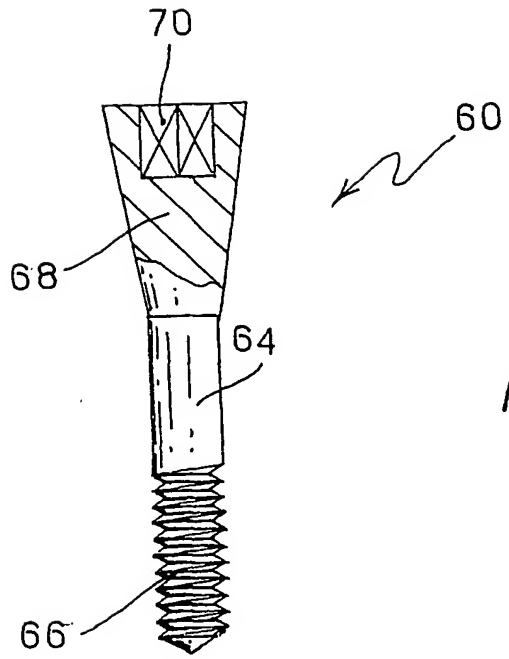

FIG. 8

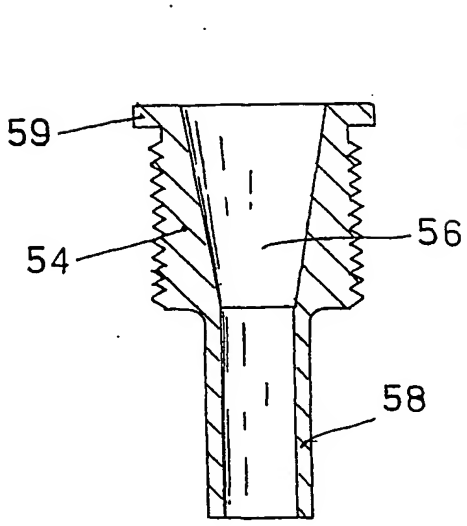

FIG. 9

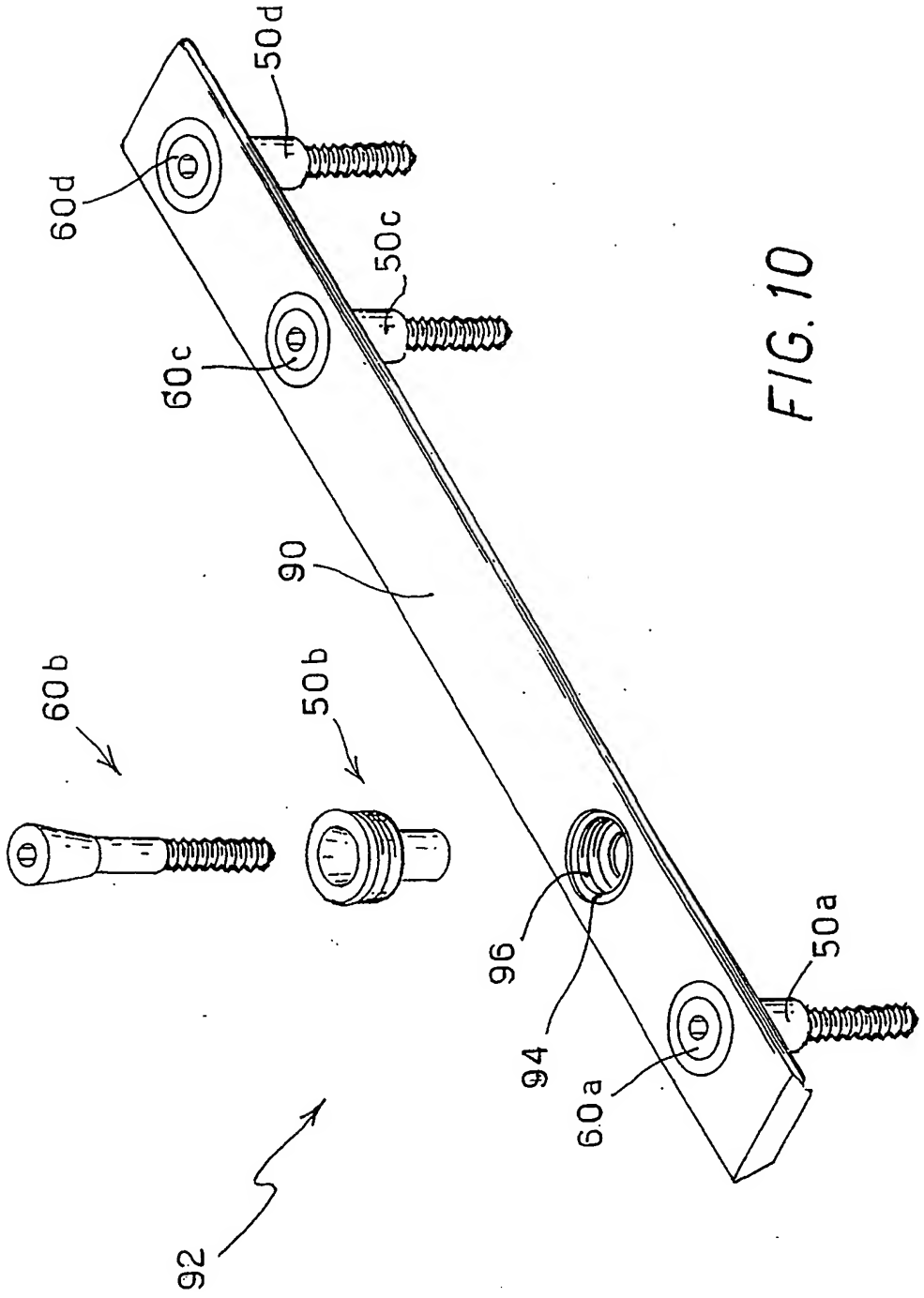

FIG. 10

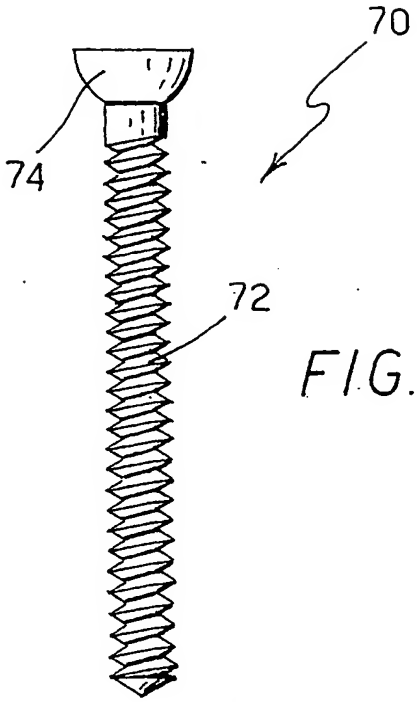

FIG. 11

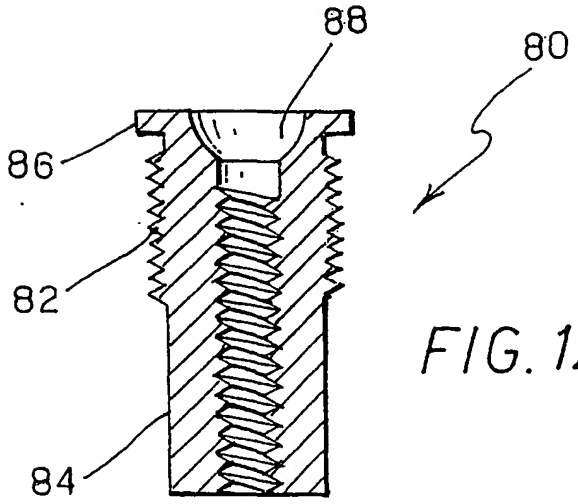

FIG. 12

INTERNATIONAL SEARCH REPORT

Int nal Application No
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A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A61B17/80 A61B17/74

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A61B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	US 4 628 923 A (MEDOFF ROBERT J) 16 December 1986 (1986-12-16) abstract; figures 1,2 column 3, line 48-53	5,6

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
7 November 2001	15/11/2001

Name and mailing address of the ISA	Authorized officer
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Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Int nal Application No
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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Information on patent family members

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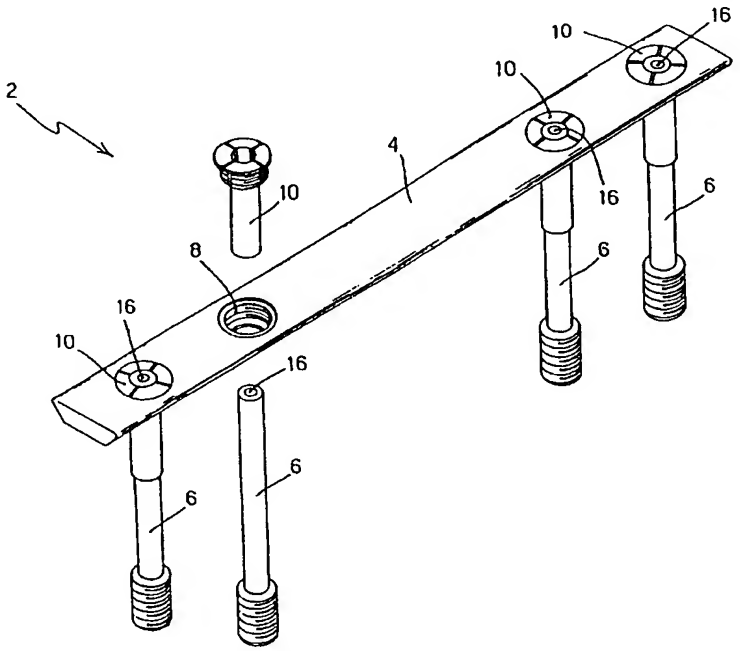
(54) Title: DEVICE FOR FIXING A BONE PLATE



(57) Abstract: A device (2) for fixing bone sections separated because of a fracture comprises a plate (4) with bores (8) for the fastening to a bone, a plurality of internally hollow barrels (10), screwed in the bores (8) of the plate (4) and a plurality of compression screws (6) adapted to be screwed in the bone and then locked in the barrels (10).

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